Systemen, planning, netwerken

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SUMMARY

This book is a report of a study aimed to investigate in how far a computer can be used for controlling a process in an organization. The choice of this subject was suggested by the fact that in recent years the development of the applications of computers has not kept step with the technical development of these machines. In particular the introduction of the so-called 'third generation computers' has caused a fracture between the actual applications and the possibilities of application. In a recent publication of the firm of management consultants, Mc. Kinsey and Company Inc., the fact just mentioned emerges very cleary as a result of an investigation with a number of computers users. The following quotation is from the report concerned: 'From a profit standpoint, our findings indicate, computer efforts in all but a few exceptional companies are in real, if often unacknowledged, trouble. Faster, costlier, more sophisticated hardware; larger and increasingly costly computer staffs; increasingly complex and ingenious applications: these are in evidence everywhere. Less and less in evidence, as these new applications proliferate, are profitable results. This is the familiar phenomenon of diminishing returns. But there is one crucial difference: As yet, the real profit potential of the computer has barely begun to be tapped' (Mc. Kinsey, 1968).

Several causes can be pointed out for this lagging behind of applications compared with the possibilities. The following ones are relevant to this investigation. Firstly, several disciplines, which concern themselves with the problem of control in organizations, have paid little or no attention to the consequences of the application of computers in organizations. This neglect, of course, led to a neglect of problems which might arise on account of the technological development of the machine itself. Secondly, the study of the complex of problems of the application is restricted to those fields in which with the aid of the computer unique results can be obtained (data processing) or optimal solutions can be found (operational research). What generally is denoted by the term 'system analysis' doesn't deserve this name. It would be

better to use the term system specification. For there is a complete neglect of an analysis how the system behaves. Only attention is paid to the conditions which must be fulfilled for the data-processing.

In this study the explanation of the behaviour of an organization is based on the behavioral approach in management science, as it has been elaborated by a number of American scientists, such as Simon, March, Cyert, Leavitt and Newell. In chapter I notions, such as organization, process, procedure and behaviour are defined. Further, in imitation of Johnsen, a number of conditions is given, with which an explicatory theory of the organization must comply. The next five conditions in this connection are mentioned by Johnsen:

1. Delineation of an arbitrary goal set
2. An explicitly formulated procedure for search in
3. An arbitrary set of decision models relating the goal set to a subset of
4. An arbitrary set of activities, and finally,
5. An explicitly formulated learning circuit.

It is shown that a relation can be made between the analysis of the organization as a system and the behavioral approach of organization problems. With the behavioral approach attention is generally paid to conditions one, three and four of Johnsen. The following notions, which are distinguished in system analysis, are described: open and closed systems, sub-system, total system and self-organizing system. Further a distinction is made between a real, iconic and symbolic system. A real system is reality. An iconic system is a mapping of reality in *such a form* that no explanation of the behaviour of the system can be derived from it, e.g. a flow chart. A symbolic system is a mapping of reality which may be used for the analysis of the behaviour of the real system.

In the study use is made on several occasions of parts of mathematics which are not included in the mathematical courses for students of economics. For that reason the following notions are defined or described in chapter I: set, sub-set, proper subset, null set, finite set, mapping, one-to-one correspondence, relations, reflexive relations, symmetric relations, transitive relations, equivalent sets, partially ordered sets, well-ordered sets, graph, node, arc, incidence, path, loop, circuit, chain, branche, link, network, tree, precedence diagram, event, slack, positive degree, project time, critical path, critical activities, dummy activities, vertex matrix, incidence matrix, triangular matrix, next assembly quantity matrix, total requirement vector matrix.

The relations between a number of these notions are discussed. At the end of the chapter it is shown that for the solution of many economic problems it may be useful to make use of the fact that the problem can be formulated in a matrix which, even though it should not be strictly triangular, complies with this condition for important partitions of the matrix. In that situation for the numeric solution of the problem use can be made of the partial ordering, which causes a triangular matrix. By sorting the rows of the matrix only certain blocks of equations from the matrix need to be solved simultaneously. In this way it is possible to solve matrices of large size without inverting the whole matrix.

The notion 'control' is used in two senses, which are denoted as control I and control II. Control I stands for 'managing'; it is used in a wide sense, namely that of taking measures to have a process run 'better'. Control II stands for a more restricted sense of the word. Control is then used, as it is mostly applied in cybernetics, as the automatic reacting to a deviation between norm and reality. If one wants to manage a process in an organization a choice can be made between two groups of expedients that might be used in order to attain this end. These two groups of measures are that of planning and control II. In chapter II and III attention is especially paid to the measures of planning. Planning is defined as the solution of endogenous variables in an explicitly or implicilty formulated model. In order to find a solution the expected values of the exogenous variables must be estimated and the values of the lagged endogenous variables must be calculated. It is shown in chapter II that in relation to the solution of planning problems a distinction has been made between the allocation and the co-ordination function of planning. From these functions result the allocation and co-ordination plan respectively. In a co-ordination plan it is determined what articles in what quantities in a number of short periods during a medium long period must be produced (short period is the number of working-days in a month; medium long period is anything up to one year). In the allocation plan it is determined at what moment production factors must be applied for the manufacture of parts of orders. At the same time it is specified how much time the production will require and in what way it will be executed. It is shown that in solving the allocation problem two expedients are used, namely the scheduling and the sequencing. It is not right, as is sometimes done in the literature on this matter, to consider one of these two expedients the very expedient for the solution of the allocation problem. The distinction between both plans is artificial but necessary for reasons of arithmetical nature. On account of the large number of combinations possible in the case

of allocation plans optimal solutions cannot be found within an economically acceptable time. In chapter II it is further more investigated in how far in economic theory and in operational research a solution for making an allocation plan is given. It appears that in economics this is not the case. In operational research the techniques of linear programming, integer programming and dynamic programming prove not to be applicable to the general case of the allocation problem, in which the starting-point is m jobs and n shops. In certain cases solutions may be found with small values of m and/or n. Apart from this, branch and bound methods, simulation, the waiting-time theory and heuristic procedures may be used. Especially these last two have been most succesful in solving allocation problems.

If one wants to use computers to manage a process in an organization, attention will have to be paid to the possibility of using the computer for data reduction and data analysis. Too little use is being made of the possibility of having the computer supply data with informative value. If this possibility is turned to account, one may speak of an information system. In chapter III it is first of all investigated with what conditions an information system must comply. The computer system must be looked upon as part of the information system. The relations between a computer system and an information system are examined. An information system also comprises an iconic and symbolic system. In chapter III it is investigated in how far with the aid of 'search and learn procedures' and with the aid of the computer the conditions two and five of Johnsen can be given any meaning. It may be inferred that in the explicatory theory these conditions may be specified, but that in the applied theory, with the development of information systems, they cannot be fulfilled. The most important reasons for this are that the existing 'search and learn procedures' have too little flexibility for computers to discern fast enough changes in the environment, while moreover too little attention has been paid by the various disciplines to the possible states in which an information system might be.

The subject-matter of the investigation is therefore divided into two parts. In the first place the question in how far computers can be used for the automation of the process of planning; in the second place the question whether the degree of connection between the various parts of an order exercises any influence on the results of the production planning. In chapter III it is shown that with the aid of the programmes developed it is possible for the computer to automatize the planning and control II of the production. It is also shown that this is possible in both the case of part production and for the small batch and large batch production. The starting points for drawing up these

programmes, in which use is made of heuristic procedures, are explained. As an iconic system for the representation of the technical data of an order a network is used. In the case of part production this is logical. There are no principal differences between the situation of part production and the usual application of the network planning techniques in project planning, especially in the case of the multi-project scheduling. In the cases of small batch and large batch production the network has, beside the specification of the ordering, the function of parts listing.The allocation plan is drawn up in two runs. In the first run the time-calculation is made, taking into account the delivery data, per order specified in a network. In the second run the activities – jobs – are allocated per shop. In the case of small batch and large batch production the effects of a learning curve are taken into account. The relation is explained between an allocation plan, drawn out in such a way, and the application of the results from the waiting-time theory, in particular the use made of the priority rules. It is argued that waiting-time theory does not draw up a plan, but that is gives rules for control II.

In chapter IV the coherence between co-ordination – and allocation plan is expounded. For drawing up the co-ordination plan, and the subsequent cost-price calculation, use is made of linear programming. It is then shown that starting from the optimal solution, which has been obtained with the aid of linear programming, and making use of matrix account the cost-prices per article can be calculated. This approach links up with the formulation of the cost-price calculation that has been given in chapter II, only with this big difference that a number of notions can now be provided with a quantitative meaning. Further the relation and the difference between planning and control II are discussed in chapter IV. It is demonstrated that it is desirable, in view of data processing, to distinguish between the two notions. The set of techniques which qua function and meaning are to be found between these two notions are denoted as techniques for correction (control III). Especially learning plays an important part in applying these techniques.

In chapter IV there is also a discussion of the outlines of a programme to control the production (control II). Moreover it is pointed out how the data processing can be integrated into the programmes developed in this study. Finally it is strongly urged to start an investigation into the contents and meaning of system analysis. We think it not right to consider system analysis a part of one of the disciplines such as economic theory, operational research or auditing, which at present concern themselves directly or indirectly with problems of automation.

The question in the first part of the subject-matter of this investigation can be answered positively. From the study of the results of a number of simulations, discussed in chapter V, it appears that also the question put in the second part would have to be answered positively. Particularly in the case of part production the degree of connection in a network appears to have a great influence on the results of the production planning. No general verdict can be returned on the influence of the sorting criterions which were used in the case of the programmes for part-production. In most cases a sorting according to shortest operation time proved to give worse results than a sorting according to a priority index. The priority index was found by taking into account the total slack and the positive degree of a job. In the case of small batch and large batch production the learning curve appears to exercise such an influence that it must be doubted if the approach followed would not have to be improved. It appeared from the results very clearly that using the formula for the economic order quantity both increases the costs and delays the execution of the production.

The information system proposed complies at least in two respects with the conditions which should be made to any information system. In the first place the administrative procedures and certain techniques from operational research have been integrated. The great advantage of applying computers is to be found in this very integration. This advantage is a result of the fact that the rapid data processing with the aid of computers makes it possible to obtain a way of making decisions which is more consistent and is based on more data. In the second place an integration has been brought about in the field of production planning. A number of the problems which are solved in this study with the aid of the programmes mentioned can be solved in other ways, in which computers are used, by successively making use of different programmes. The very application of large computers makes it possible to bring about this integration and makes this integration the condition for the application.